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Michael A. Krupa
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CNRO-2003-00057

October 24, 2003

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

SUBJECT: Entergy Operations, Inc.
Response to a Request for Additional Information Pertaining to Relaxation Request to NRC Order EA-03-009 for the Control Element Drive Mechanism Nozzles

Waterford Steam Electric Station, Unit 3
Docket No. 50-382
License No. NPF-38

REFERENCE: Entergy Operations, Inc. letter CNRO-2003-00038 to the NRC, "Relaxation Request to NRC Order EA-03-009 for the Control Element Drive Mechanism Nozzles," dated September 15, 2003

Dear Sir or Madam:

In the referenced letter, Entergy Operations, Inc. (Entergy) requested relaxation from Section IV.C(1)(b) of NRC Order EA-03-009 for Waterford Steam Electric Station, Unit 3 (Waterford 3) via Waterford 3 Relaxation Request #1 pertaining to the control element drive mechanism (CEDM) nozzles.

In a recent telephone conversation with Entergy representatives discussing Waterford 3 Relaxation Request #1, the NRC staff requested additional information to support review and approval of the request. This information is provided in the enclosure.

This letter contains no new commitments.

If you have any questions or require additional information, please contact Guy Davant at (601) 368-5756.

Sincerely,

M. A. Krupa

MAK/GHD/bal

Enclosure: Response to Request for Additional Information
cc: (see next page)

A101

cc: Mr. W. A. Eaton (ECH)
Mr. J. E. Venable (W3)
Mr. G. A. Williams (ECH)

Mr. N. Kalyanam, NRR Project Manager (W3)
Mr. M. C. Hay, NRC Senior Resident Inspector (W3)
Mr. B. S. Mallett, NRC Region IV Regional Administrator

ENCLOSURE

CNRO-2003-00057

RESPONSE TO A REQUEST FOR ADDITIONAL INFORMATION

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In a telephone call held on October 21, 2003 with Entergy representatives discussing Waterford 3 Relaxation Request #1, the NRC staff requested additional information to support review and approval of the request. The requests and associated responses are provided below.

NRC Request 1:

Please provide the heat numbers for the Waterford 3 control element drive mechanism (CEDM) nozzles and any industry inspection history.

Entergy Response:

The CEDM nozzles at Waterford 3 were supplied by Standard Steel and fabricated from the following heat numbers and material forms:

- A08846, SB-166
- A09042, SB-166
- A09321, SB-166

Industry history of known cracking for heats of Alloy 600 material used in Combustion Engineering CEDM nozzles are provided in the table below.

Heat	Form	Supplier	Total # of Nozzles	# of Nozzles with Cracks
A6785	SB-166	Standard Steel	9	1
E03045	SB-166	Standard Steel	35	1
NX1045	SB-167	Huntington Alloy	58	3

As seen from the information presented above, the Waterford 3 CEDM nozzles were not fabricated from the heats that have exhibited cracking.

NRC Request 2:

The analysis used to support the Waterford 3 Relaxation Request #1 was based on ultrasonic testing (UT) data from a sister plant. What as-found conditions, based on the planned UT inspections of the CEDM nozzles would necessitate reanalysis to ensure compliance with NRC Order EA-03-009?

Entergy Response:

In an effort to identify what as-found conditions would require reanalysis, Entergy has performed an evaluation of the variables that could negatively affect the current analysis[1]. From this evaluation, the one variable that has the potential to negatively affect the current analysis is the distance between the top of the blind zone and the bottom of the weld when this distance is shortened by a reduction in the nozzle length. To further assess this affect, an iterative analysis using varying lengths between the blind zone and the bottom of the weld has been performed to identify the threshold length that would require an augmented inspection.

An in-depth discussion of the iterative analysis is provided in the attachment to this enclosure. As explained in the attachment, when the available propagation length (distance between the blind zone and the bottom of the weld) is reduced to a distance equal to or less than the calculated crack length for one operating cycle, an augmented inspection will be required. This minimum propagation length has been determined for each nozzle group and becomes the threshold for triggering an augmented inspection. The table below compares the available propagation length assumed in the original analysis to the minimum propagation length required to prevent an assumed crack from reaching the weld during an operating cycle. If the as-found length of a CEDM nozzle causes the length between the top of the blind zone to the bottom of the weld to be equal to or less than the "Minimum Propagation Length", an augmented inspection will be performed. The only remaining analysis would be to determine the circumferential extent of the augmented examination coverage.

Nozzle Group (Head Angle Degrees)	Assumed Available Propagation Length (inch)	Minimum Propagation Length (inch)
0	1.029	0.265
7.8	1.002	0.250
29.1	0.637	0.160
49.7	0.420	0.160

[1] Submitted via Entergy letter CNRO-2003-00038, dated September 15, 2003.

NRC Request 3:

Please provide a description of the eddy current testing (ECT) instrumentation to be utilized in the augmented inspections of the CEDM nozzle blind zone area, if required.

Entergy Response:

As discussed in Waterford 3 Relaxation Request #1[2], Entergy does not expect to perform augmented inspections of the CEDM nozzle blind zones. However, if such augmented inspections are required, Entergy intends to use the ECT method as the primary surface examination method and employ equipment similar to that used at Arkansas Nuclear One, Unit 2 (ANO-2) (see Figure 1). A description of the ECT equipment used at ANO-2 was provided to the NRC staff in Entergy letter CNRO-2003-00047, dated September 25, 2003.

Entergy recognizes the NRC staff's expectation that inspections be performed to the maximum extent possible. Accordingly, Entergy intends to meet these expectations with ECT inspection equipment designed to the following objectives:

1. Inspection coverage bounds the portion of the blind zone and inspects the nozzle surface to the maximum extent possible.
2. The equipment can be consistently applied to all CEDM nozzle locations requiring inspection.
3. The equipment setup and operation minimizes radiation exposure.
4. The equipment setup and operation minimizes operator error.

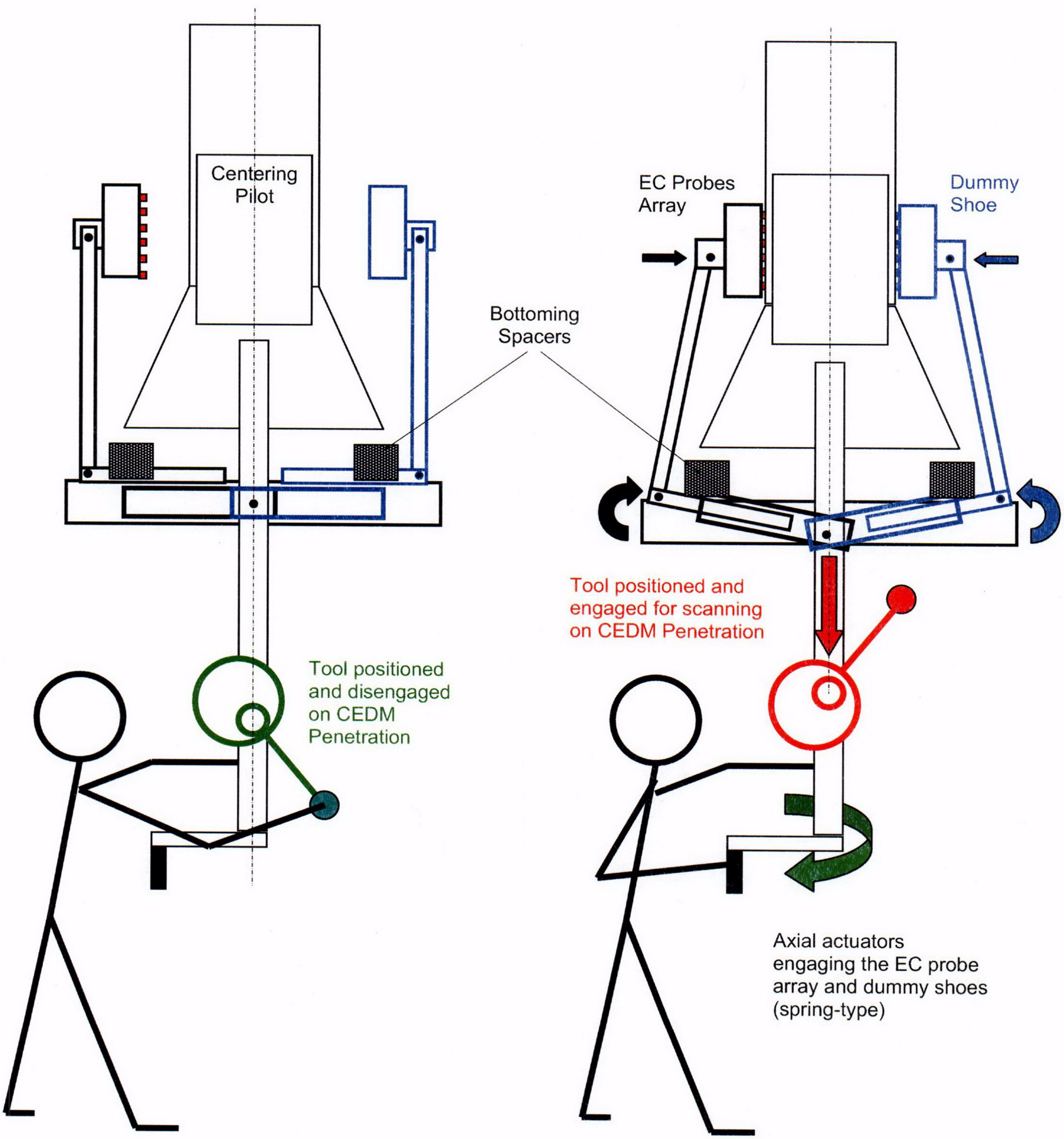
The planned ECT inspection tool (sled) is designed with arrayed "plus point" ECT coils that allow a single scan to be performed without multiple setups. Scan lengths prevent interference issues associated with the guide cones and steep angles on the outer nozzle rows. The scan length is fixed by the design of the inspection tool and the size of the ECT coil block. The position of the ECT coil block is fixed relative to the vertical axis of the nozzle.

If utilized, the ECT inspection equipment is manually installed on each CEDM nozzle and manually operated. The ECT equipment can inspect the nozzle from the top of the blind zone down 0.8 inch.

[2] Ibid.

FIGURE 1

ECT INSPECTION TOOL FOR CEDM NOZZLE BLIND ZONE



C01

ATTACHMENT

BASES FOR AUGMENTED INSPECTION TRIGGERS

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The analyses presented in Engineering Report M-EP-2003-004 (Reference 1) was based on the information obtained from Waterford 3 design drawings and UT data from a sister plant. Entergy evaluated the information from these two sources and discovered that the J-weld joining the nozzle tube to the reactor vessel head (RVH) may be larger than depicted in the design drawings. The evaluation that was performed is presented in Reference 1. The change in weld size for the four nozzle groups selected for the analysis is presented in Figures 1 through 4.

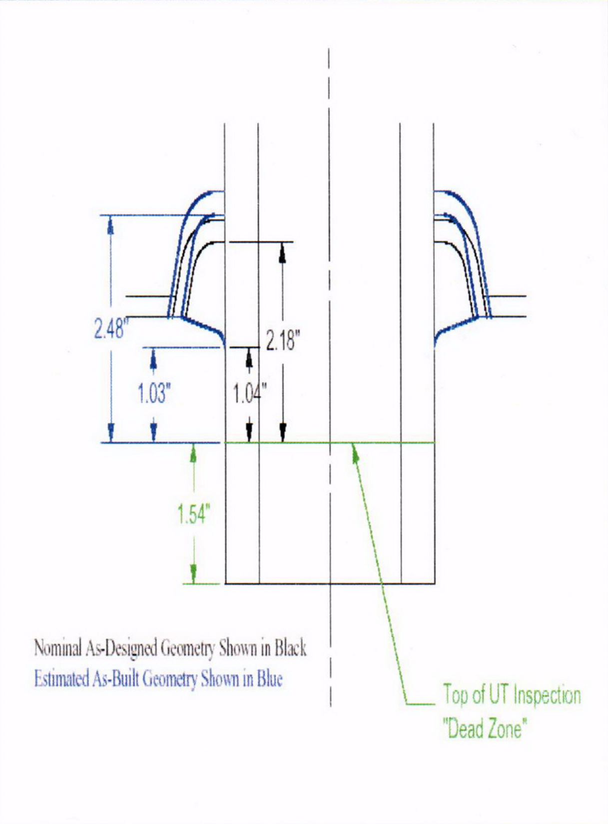


Figure 1: *0° nozzle showing the differences between as-designed and the as-analyzed based on sister plant UT data.*

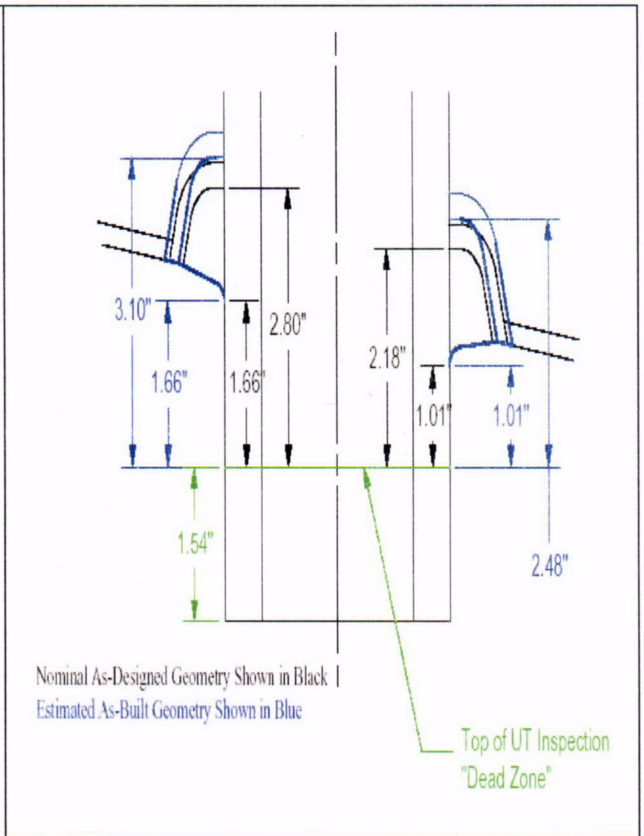


Figure 2: *7.8° nozzle showing the differences between as-designed and the as-analyzed based on sister plant UT data.*

Figures 1 and 2 show the differences between the as-designed condition and the as-built condition (inferred from sister plant UT data) for the nozzle at the center and the group close to the central nozzle. From these figures, it is evident that the larger weld size resulted in an increase in the weld length along the nozzle bore. The fillet-cap weld size remained unchanged. Also, the available propagation lengths (the distance from the bottom of the weld to the top of the blind zone) for cracks below the weld bottom remain unchanged between the two conditions.

CO2

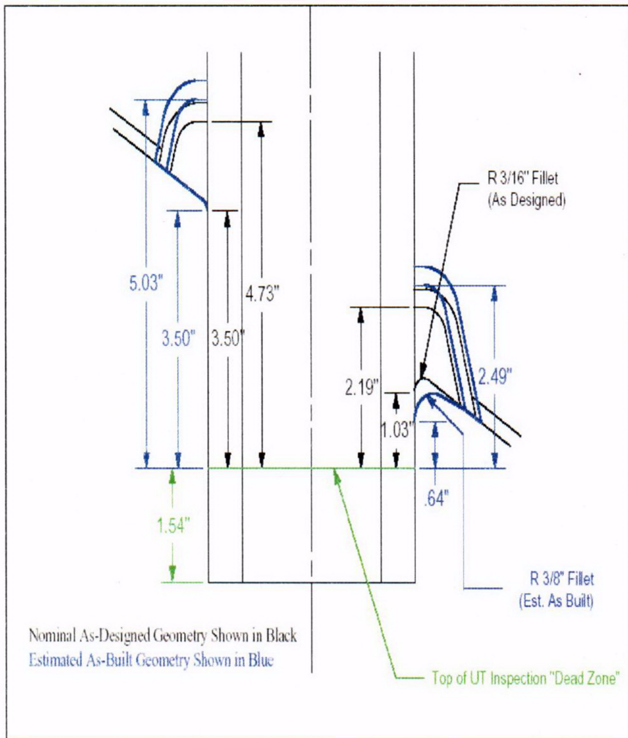


Figure 3: *29.1° nozzle showing the differences between as-designed and the as-analyzed based on sister plant UT data.*

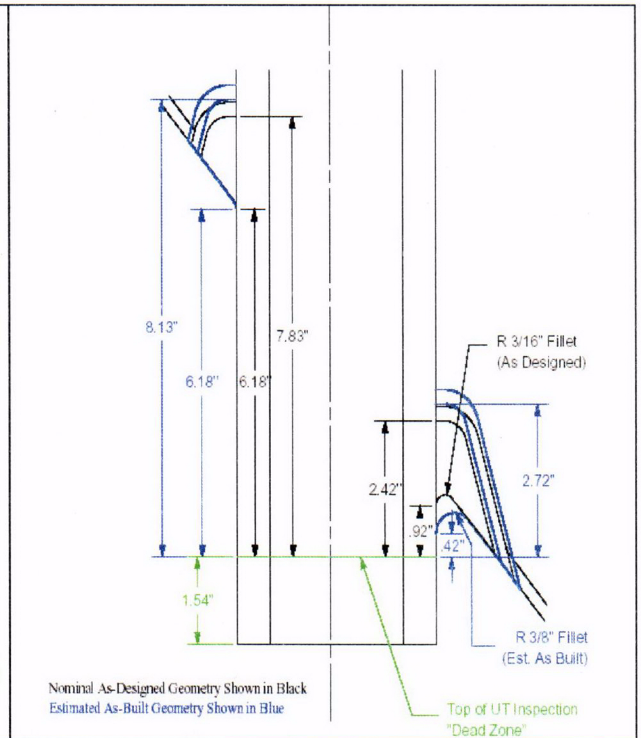


Figure 4: *49.7° nozzle showing the differences between as-designed and the as-analyzed based on sister plant UT data.*

Figures 3 and 4 show the evaluation results for the nozzle groups in the middle region (29.1°) and the outermost region (49.7°). These figures indicate the following:

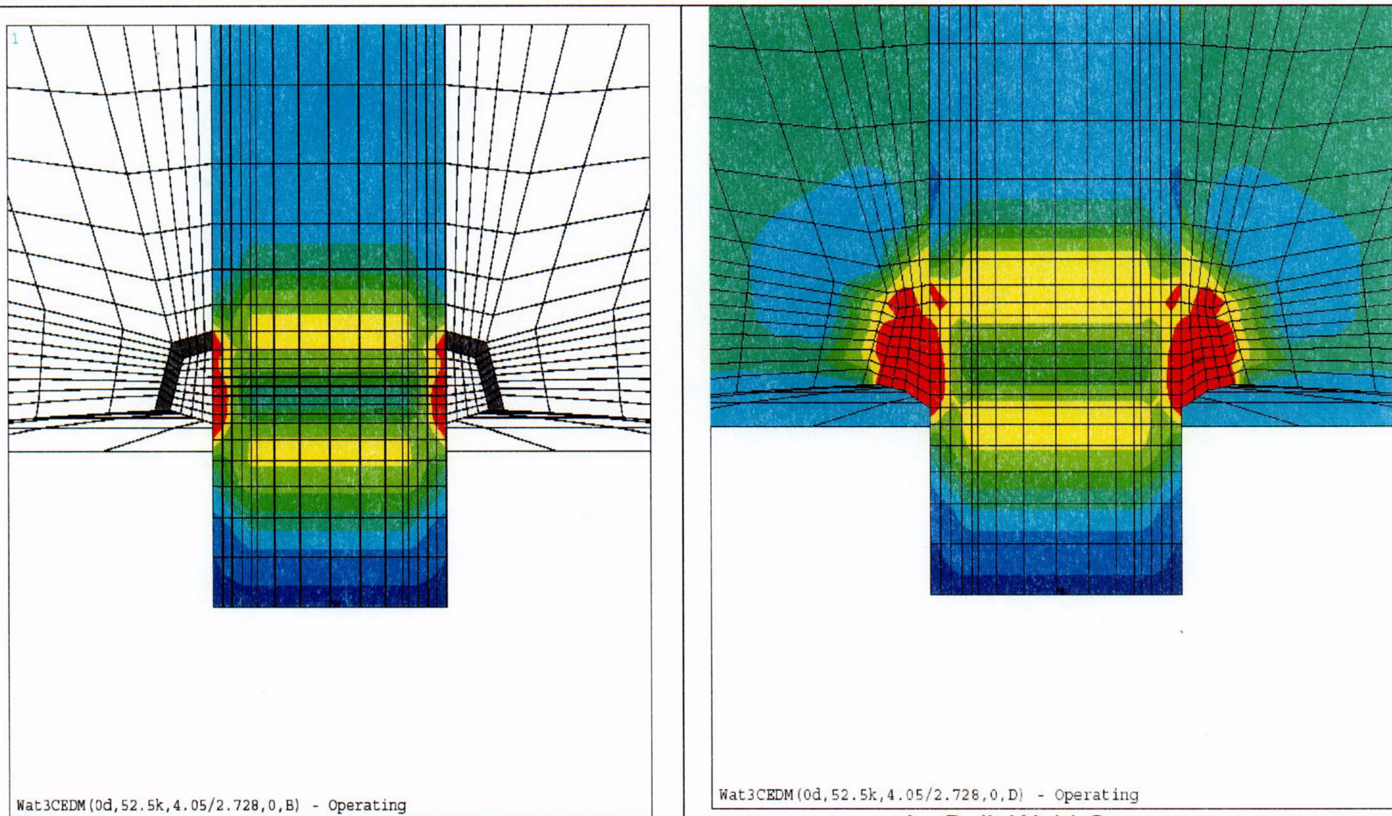
- The weld length along the nozzle bore has increased;
- The available propagation length on the uphill side remains unchanged; and
- The fillet-cap weld size on the downhill side has increased.

The increase of the fillet-cap weld size on the downhill side, in-turn, reduces the available propagation length. This reduction in the available propagation length will have an impact on the fracture mechanics analysis that assesses the effect of the blind zone.

In order to assess the impact of the larger weld size on the prevailing stresses (residual plus operating) in the region below the weld, the finite element analysis data for the two designs were compared. The finite element analysis data for the as-designed condition and the proposed as-built condition were obtained from Engineering Report M-EP-2003-002 (Reference 2) and from Reference 1, respectively.

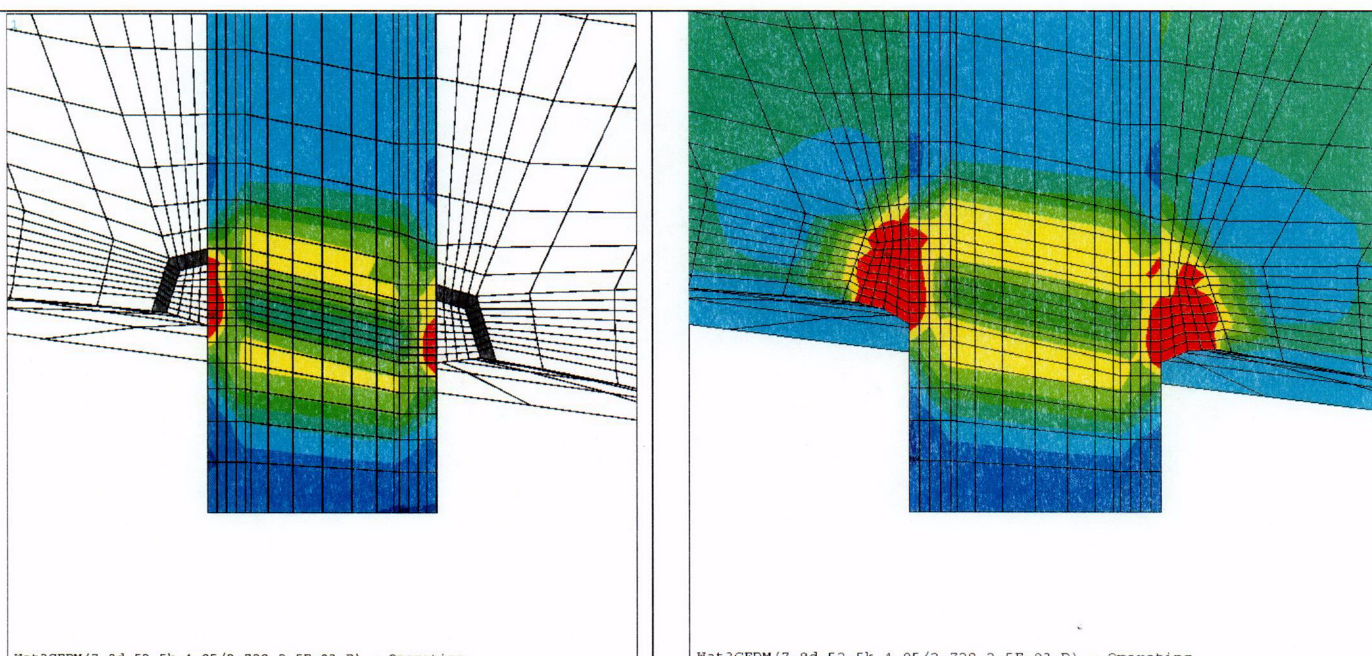
The stress contours for the four nozzle groups are presented in Figures 5 through 8. In these figures, the important aspect to consider is the stress distribution contours in the nozzle below the weld. The stress distribution in this region will contribute to the crack growth; therefore, the impact of the larger weld on this stress distribution is of interest.

C03



As-Designed Weld Geometry | As-Built Weld Geometry

Figure 5: *0° nozzle comparison of stress contours for the as-designed versus as-built weld sizes. The stress contours below the weld in both cases are similar.*



As-Designed Weld Geometry | As-Built Weld Geometry

Figure 6: *7.8° nozzle comparison of stress contours for the as-designed versus as-built weld sizes. The stress contours below the weld in both cases are similar.*

C04

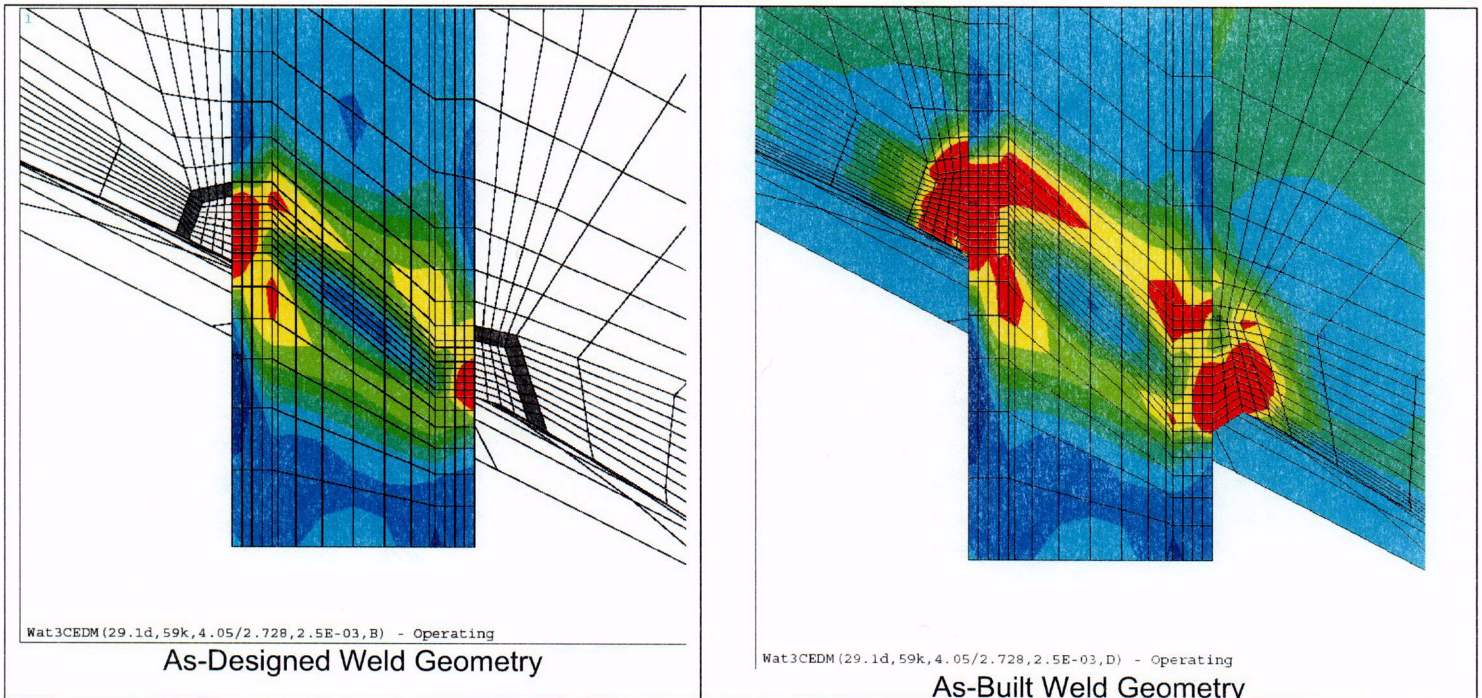


Figure 7: *29.1° nozzle comparison of stress contours for the as-designed versus as-built weld sizes. The stress contours below the weld in both cases are similar.*

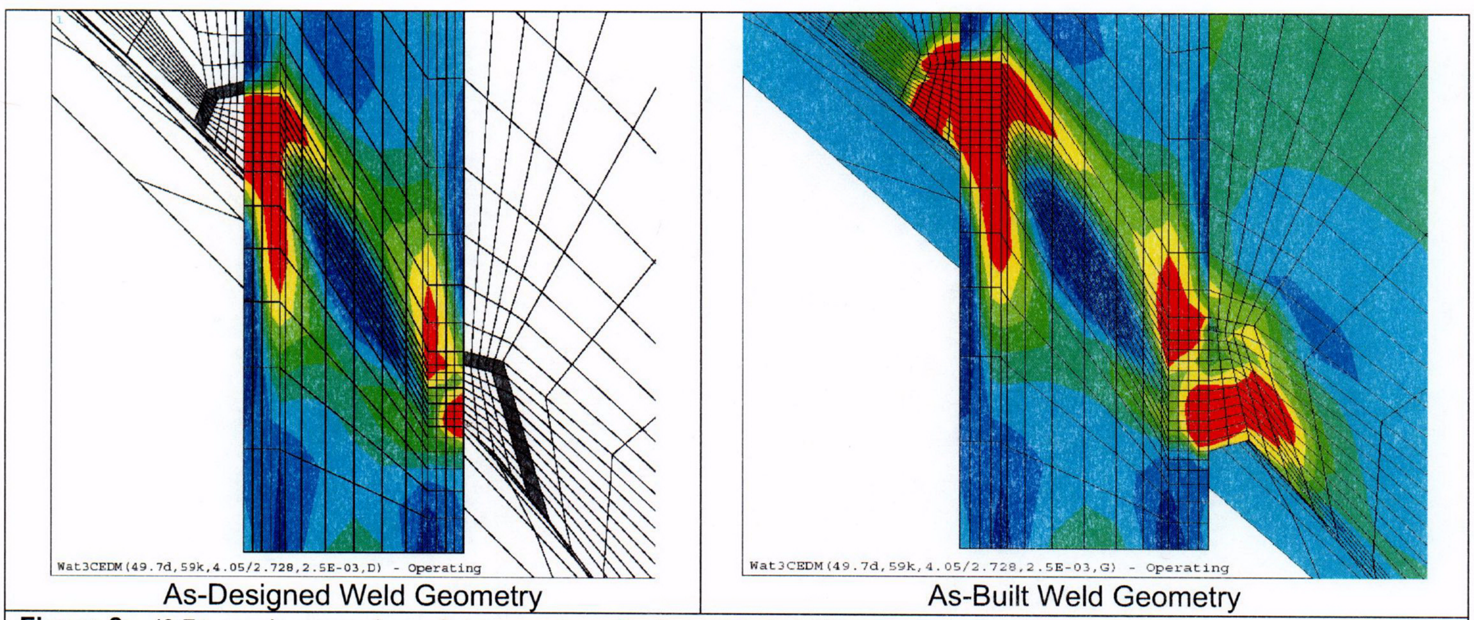


Figure 8: *49.7° nozzle comparison of stress contours for the as-designed versus as-built weld sizes. The stress contours below the weld in both cases are similar. On the downhill side, the region of compression-to-low tensile stress becomes larger for the larger weld size in the as-built geometry.*

From the figures above, it is observed that the larger weld size does not impact the residual stress distribution below the weld (region of interest), as depicted by the stress contours. The increase in the fillet-cap weld on the downhill side for the outermost nozzle group (49.7°) causes lower stress levels below the weld. The nodal stresses on the inside diameter (ID) and outside diameter (OD) surfaces for the two weld geometries, for all four nozzle groups, were evaluated and are presented in Figures 9 through 12.

C05

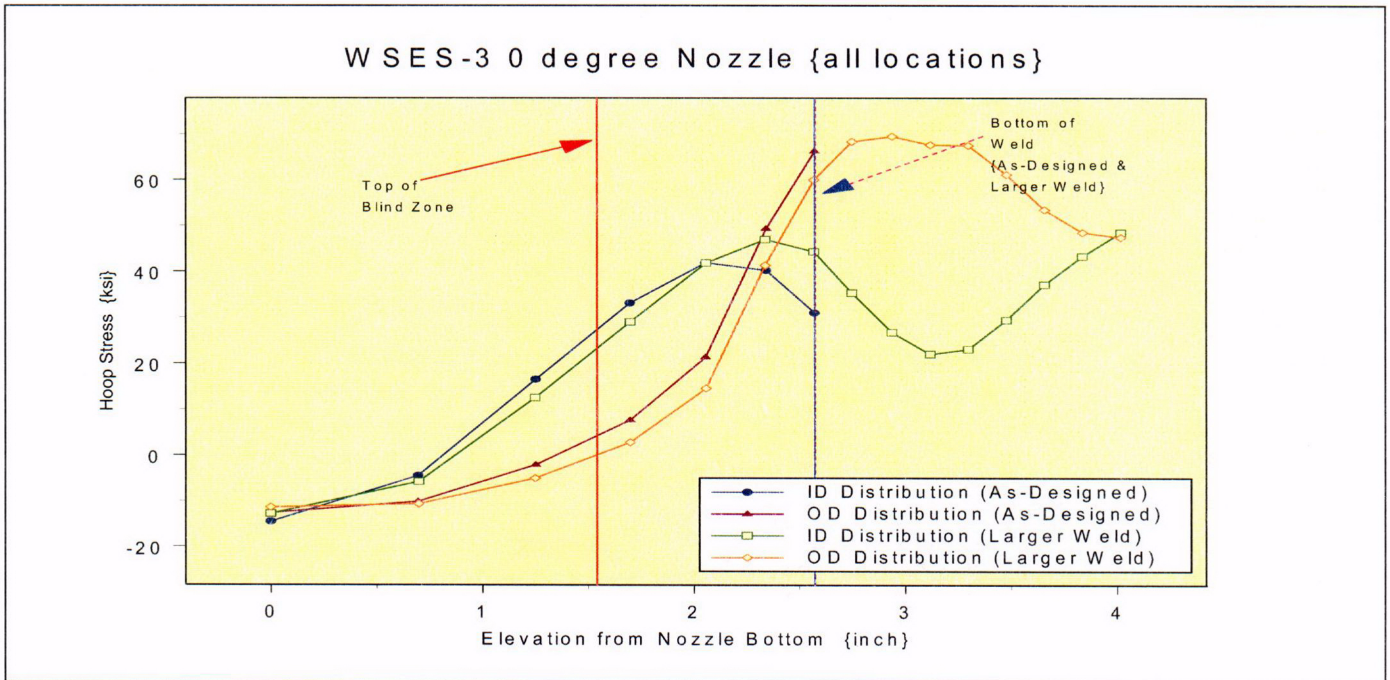


Figure 9: *Plot of nodal stresses on the ID and OD surfaces for the two weld geometries evaluated. The top of the blind zone is shown in red and the bottom of the weld is coincident. The stress profiles, in the region of interest (between the top of blind zone and the bottom of weld), are very similar and within a 5.0 ksi spread.*

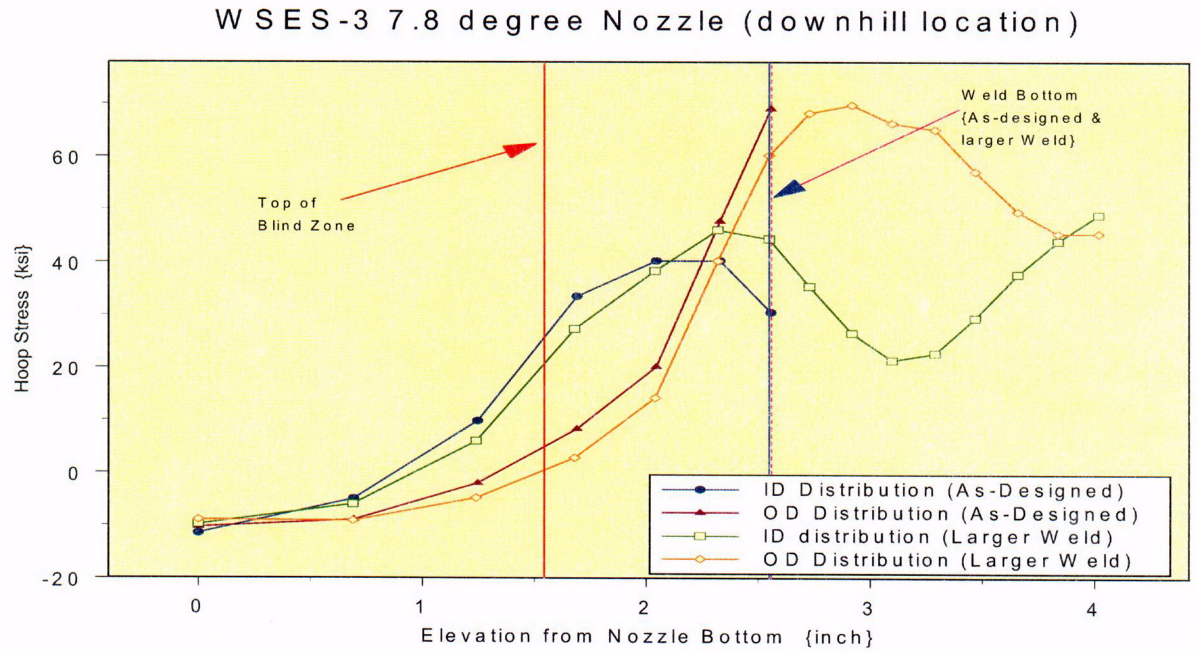


Figure 10: *Plot of nodal stresses on the ID and OD surfaces for the two weld geometries evaluated. The top of the blind zone is shown in red and the bottom of the weld is coincident. The stress profiles, in the region of interest (between the top of blind zone and the bottom of weld), are very similar and within a 5.0 ksi spread.*

C06

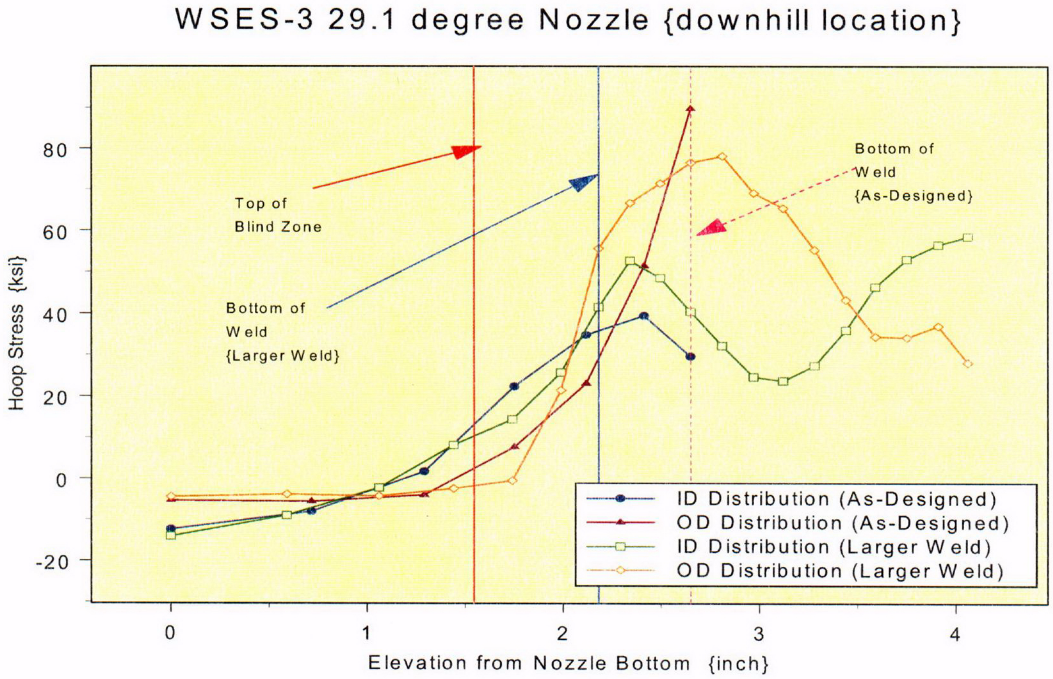


Figure 11: *Plot of nodal stresses on the ID and OD surfaces for the two weld geometries evaluated. The top of the blind zone is shown in red and the bottom of the weld is shown in magenta for the as-designed geometry and in light blue for the as-built geometry. The lowering of the weld bottom is due to the increase in the fillet-cap weld size. This has the effect of reducing the available propagation length. The stress profiles, in the region of interest (between the top of blind zone and the bottom of weld), are very similar and within a 5.0 ksi spread. The as-built profiles are generally higher than the as-designed profiles.*

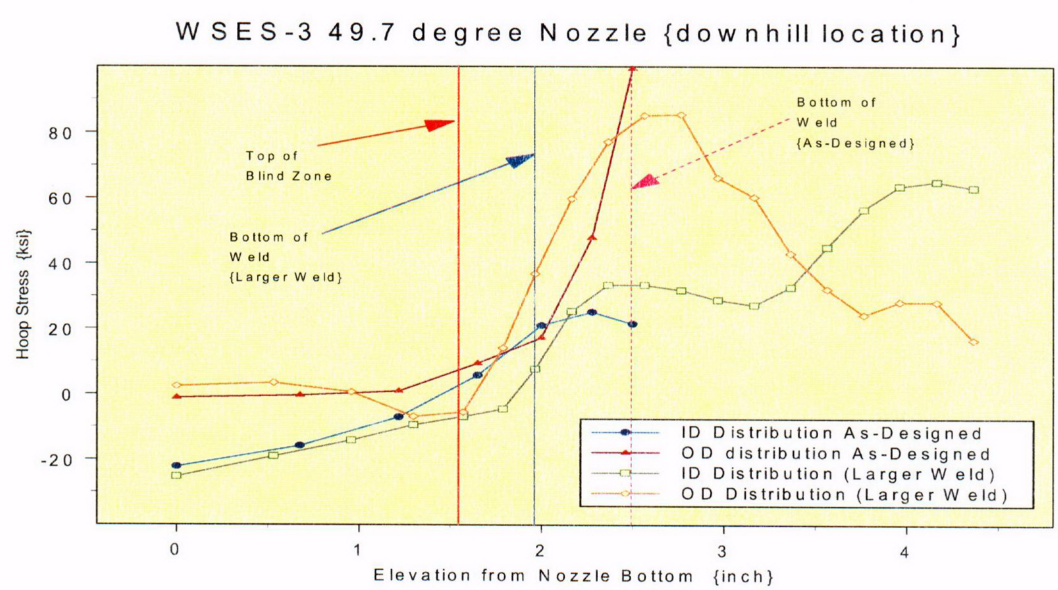


Figure 12: *Plot of nodal stresses on the ID and OD surfaces for the two weld geometries evaluated. The top of the blind zone is shown in red and the bottom of the weld is shown in magenta for the as-designed geometry and in light blue for the as-built geometry. The lowering of the weld bottom is due to the increase in the fillet-cap weld size. This has the effect of reducing the available propagation length. The stress profiles, in the region of interest (between the top of blind zone and the bottom of weld), are very similar and within a 5.0 ksi spread. The as-built profiles are generally higher than the as-designed profiles.*

C07

The evaluation of the nodal stresses on both the ID and OD surfaces at the downhill location for the four nozzle group show the following:

- For the two nozzle groups, the central nozzle and one group close to the RVH central region, shows that the profiles are very similar. This was expected since the fillet-cap remained unchanged and the stress contours showed no significant difference between the two geometries.

- For the two nozzle groups closer to the periphery (29.1° and 49.7°) there were two differences between the as-designed and as-built geometries. First, the stress level at the weld bottom for the as-built geometry was lower than that for the as-designed geometry. In the as-built geometry, the larger fillet-cap weld brings the bottom of the weld lower. Since the weld bottom is removed from the RVH, the constraint provided by the head no longer exists at this location. Therefore, the weld metal cools under conditions of a significantly reduced constraint resulting in a lower residual stress level. Second, the stress profile for the as-built geometry in the region of interest is slightly higher than that for the as-designed geometry. This is caused by placing the weld bottom closer to the nozzle end.

The comparison of the stress contours and the nodal stress plots at the downhill location shows that the stress analysis presented in Reference 1 remains valid for the likely weld geometries that may be found during the current inspection campaign at Waterford 3 (refueling outage RF-12). Therefore, the current stress distribution (Reference 1) can be used to assess the condition that would impact the crack growth in the region below the weld. This evaluation was performed and is discussed in the following paragraphs.

The fracture mechanics model used was for the through-wall crack geometry presented in Reference 1. The selection of the through-wall crack for this analysis is based on the inherent conservatism that exists for this geometry and was corroborated by the NRC staff in the safety evaluation approving a similar relaxation request for Arkansas Nuclear One, Unit 2 (Reference 3). The downhill location was selected for the evaluation because this is the location where the available propagation length is the smallest. Therefore, the crack model and the location chosen for the evaluation will provide a bounding analysis to answer the NRC question.

The fracture mechanics analysis simulates a shorter nozzle than that considered in the analysis presented in Reference 1 by increasing the elevation of the blind zone towards the weld bottom. Elevating the blind zone also causes a concomitant reduction of the available propagation length. This action was considered in steps of fifteen percent (15%) of the available propagation length. That is, the blind zone was elevated by 15% of the original available propagation length (initial from Reference 1) and the available propagation length was reduced by 15%. The evaluation considered several individual iterations until a condition was reached such that either:

1) The remaining available propagation length did not provide sufficient growth margin to support one fuel cycle of operation, or

2) The remaining available propagation length is 0.16 inch (to accommodate the assumed crack size based on UT detection limits) such that the needed margin for an OD surface flaw would cease to exist.

The results of the several fracture mechanics analyses using the through-wall flaw model of Reference 1 are presented in the table below.

Nozzle Group (Head Angle Degrees)	Blind Zone Elevation From Nozzle Bottom (inch)	Available Propagation Length (inch)	Crack Growth in One Fuel Cycle (inch)
0	1.544	1.029	0
	1.699	0.875	0.032
	1.852	0.720	0.072
	2.007	0.566	0.126
	2.161	0.412	0.192
	2.316	0.257	0.265
7.8	1.544	1.002	0
	1.694	0.852	0
	1.851	0.701	0.027
	1.995	0.551	0.075
	2.145	0.401	0.152
	2.296	0.251	0.247
29.1	1.544	0.637	0
	1.640	0.541	0
	1.735	0.446	0.008
	1.831	0.350	0.039
	1.926	0.255	0.087
	2.022	0.159	0.153
49.7	1.544	0.420	0
	1.607	0.357	0
	1.67	0.294	0
	1.733	0.231	0
	1.796	0.168	0

The results presented above show the existence of considerable margin before augmented inspections would be required. The rows shaded in red are the smallest available propagation length evaluated that either results in insufficient margin to accommodate a full cycle of crack growth (0° and 7.8°) or the available margin is close to the 0.16 inch required by the OD surface flaw analysis in accordance with the model in Reference 1.

Based on the results of the evaluation presented above, the trigger for requiring augmented inspections would be as follows:

- 0 degree nozzle: when the available propagation length is ≤ 0.265 inch.
- 7.8 degree nozzle: when the available propagation length is ≤ 0.250 inch.
- 29.1 degree nozzle: when the available propagation length is ≤ 0.160 inch.
- 49.7 degree nozzle: when the available propagation length is ≤ 0.160 inch.

References:

1) Enclosure 2 of Entergy Operations, Inc. letter CNRO-2003-00038, dated September 15, 2003 - Engineering Report M-EP-2003-004, Rev. 0, *Fracture Mechanics Analysis for the Assessment of the Potential for Primary Water Stress Corrosion Crack (PWSCC) Growth in the Un-Inspected Regions of the Control Element Drive Mechanism (CEDM) Nozzles at Waterford Steam Electric Station Unit 3*

2) Enclosure 3 of Entergy Operations, Inc. letter CNRO-2003-00020, dated June 11, 2003 – Engineering Report M-EP-2003-002, Rev. 0, *Fracture Mechanics Analysis for the Assessment of the Potential for Primary Water Stress Corrosion Crack (PWSCC) Growth in the Un-Inspected Regions of the Control Element Drive Mechanism (CEDM) Nozzles at Arkansas Nuclear One Unit 2 and Waterford Steam Electric Station Unit 3*

3) NRC letter to Entergy Operations, Inc., dated October 9, 2003, *Safety Evaluation by the Office of Nuclear Reactor Regulation Relaxation Request from Order EA-03-009 Regarding the Control Element Drive Mechanism Examination; Facility Operating License No. NPF-6, Entergy Operations Inc., Arkansas Nuclear One, Unit 2, Docket No. 50-368*